

Evaluating TOA Radiative Fluxes in Current Reanalyses using CERES EBAF-TOA Ed4.0

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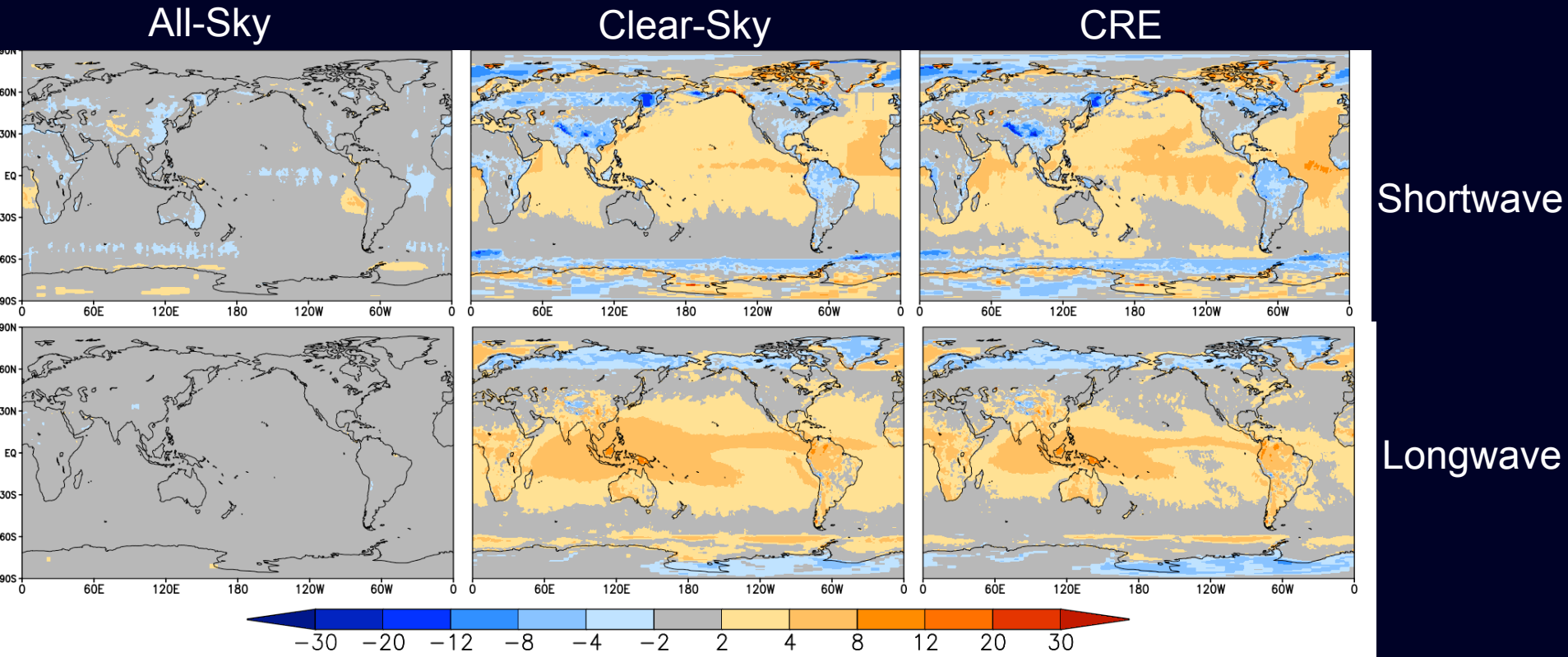
The Spring 2017 CERES Science Team Meeting
May 18, 2017

Introduction

- What is a reanalysis?
 - A consistent, global best estimate of atmospheric and land parameters obtained by combining model and observations in a data assimilation system
 - Widely used for various weather and climate studies
- Evaluation of reanalyses using observations:
 - In-situ (e.g. ARM, DYNAMO)
 - Satellite-based (e.g. CERES EBAF-TOA)
 - e.g. Wong (2014), Dolinar *et al.* (2016)

Motivation

CERES EBAF-TOA Data Development
Ed4.0 minus Ed2.8: Clim2003-2015



Q1: How does the EBAF-TOA data improvement affect the evaluation of current reanalyses?

Q2: How well do current reanalyses perform in their TOA radiation (as evaluated using EBAF-TOA Ed4.0)?

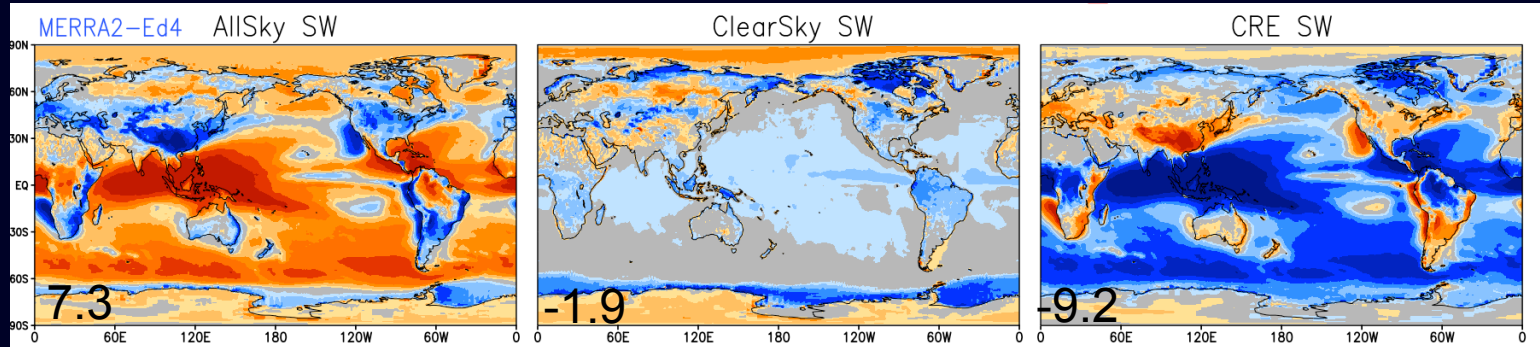
Data and Methodology

- CERES EBAF-TOA
 - Ed4.0; Ed2.8
- Reanalyses
 - MERRA-2; ERA-I
- Analysis
 - Period: Jan2003-Nov2016
 - Evaluation:
 - Mean climate
 - Year-to-year variation
 - Trend

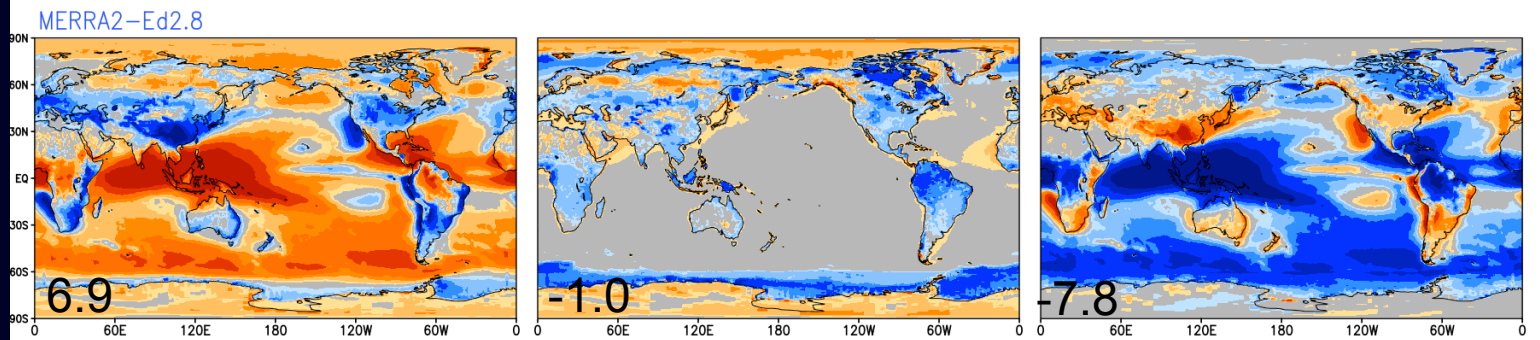
Mean Climate (2003-2015)

TOA Shortwave: MERRA-2 minus CERES

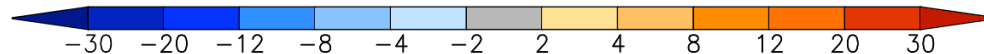
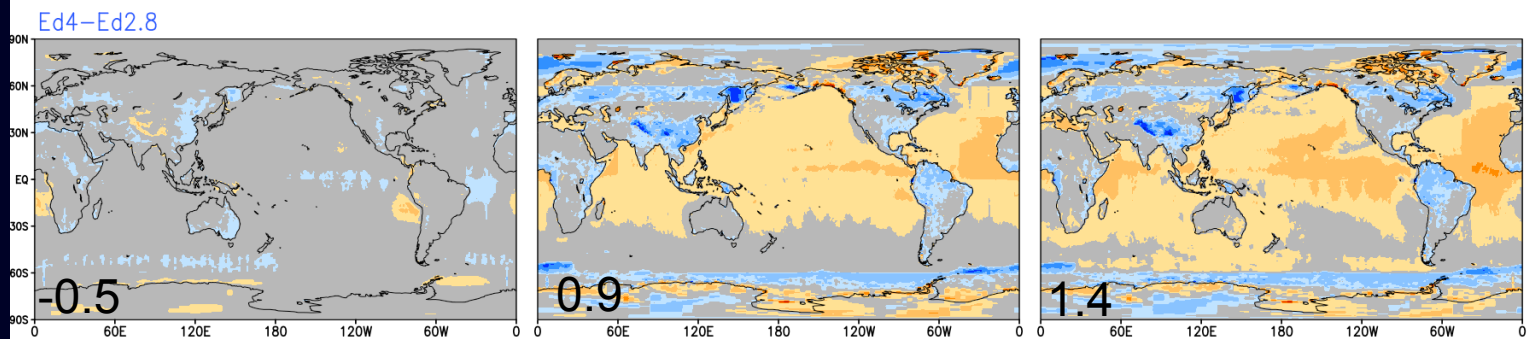
MERRA-2
minus
EBAF4.0



MERRA-2
minus
EBAF2.8



EBAF4.0
minus
EBAF2.8



All Sky

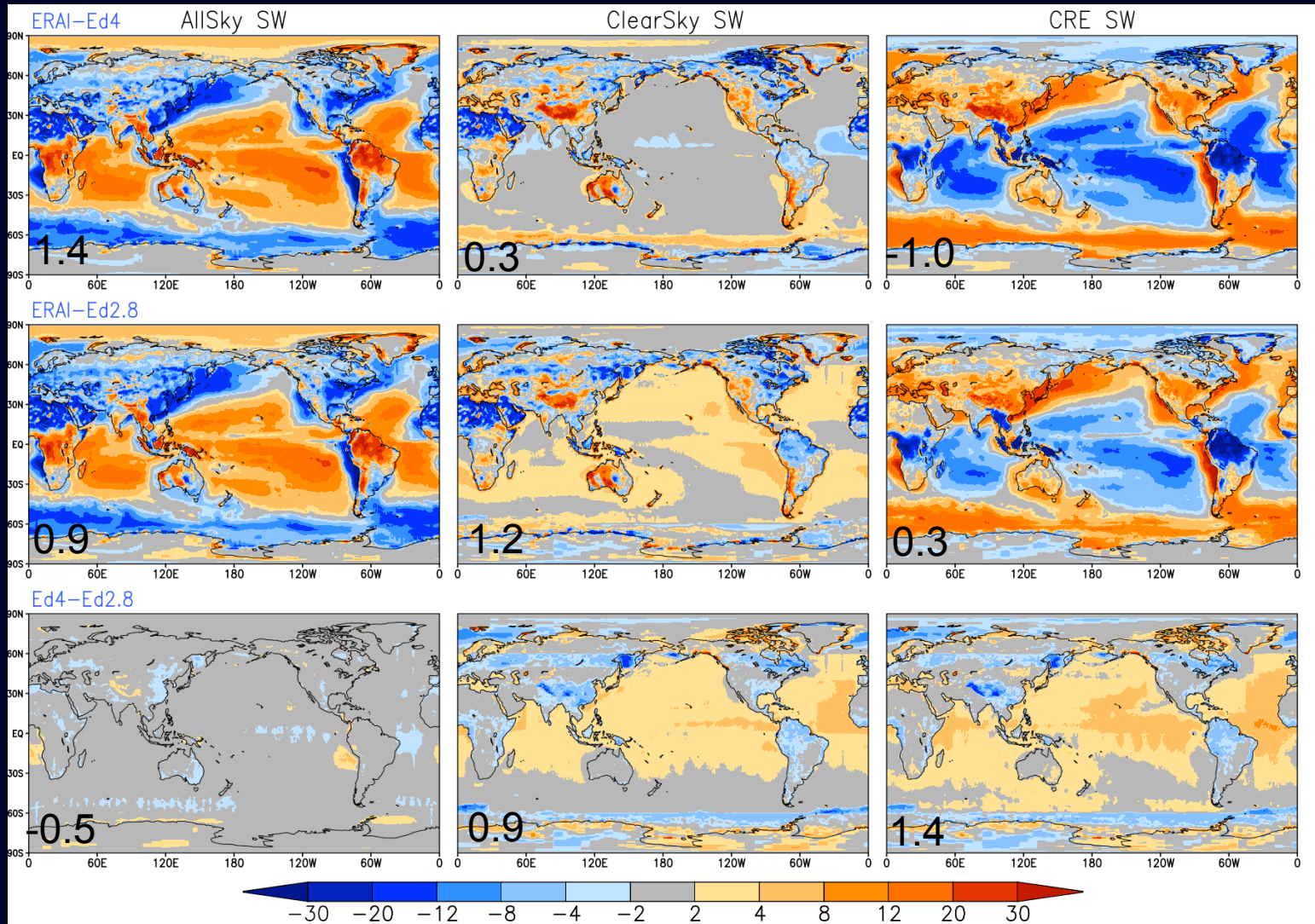
Clear Sky

CRE

Mean Climate (2003-2015)

TOA Shortwave: ERA-I minus CERES

ERA-I
minus
EBAF4.0



All Sky

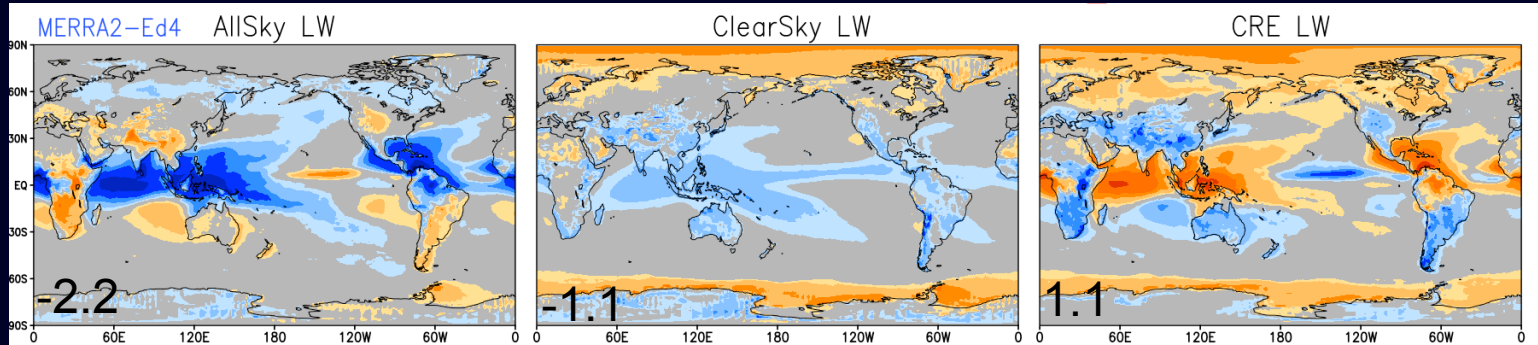
Clear Sky

CRE

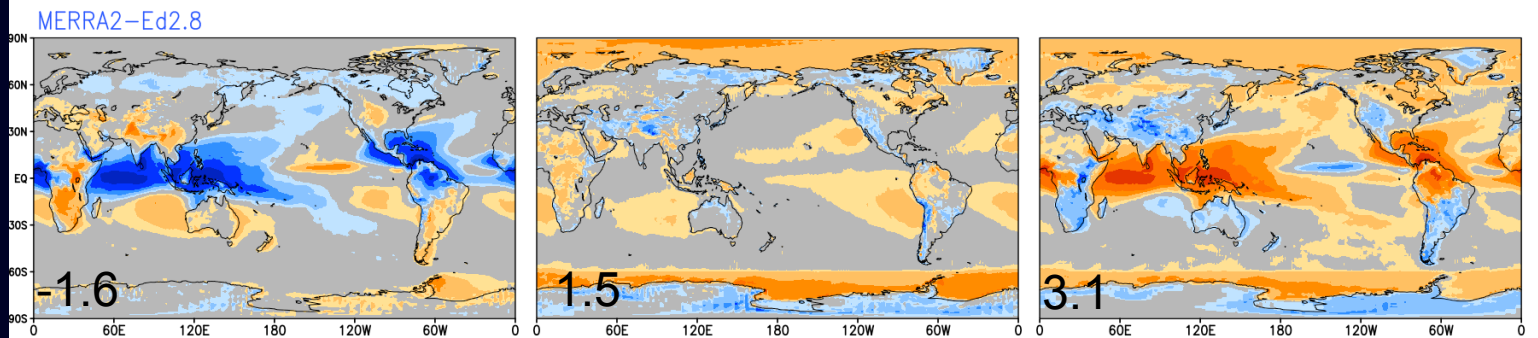
Mean Climate (2003-2015)

TOA Longwave: MERRA-2 minus CERES

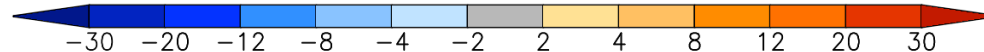
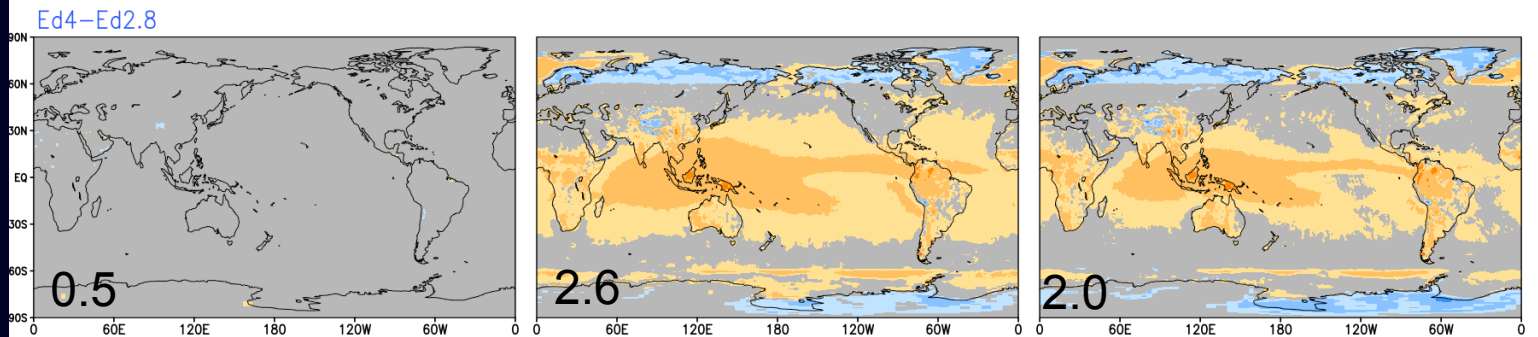
MERRA-2
minus
EBAF4.0



MERRA-2
minus
EBAF2.8



EBAF4.0
minus
EBAF2.8



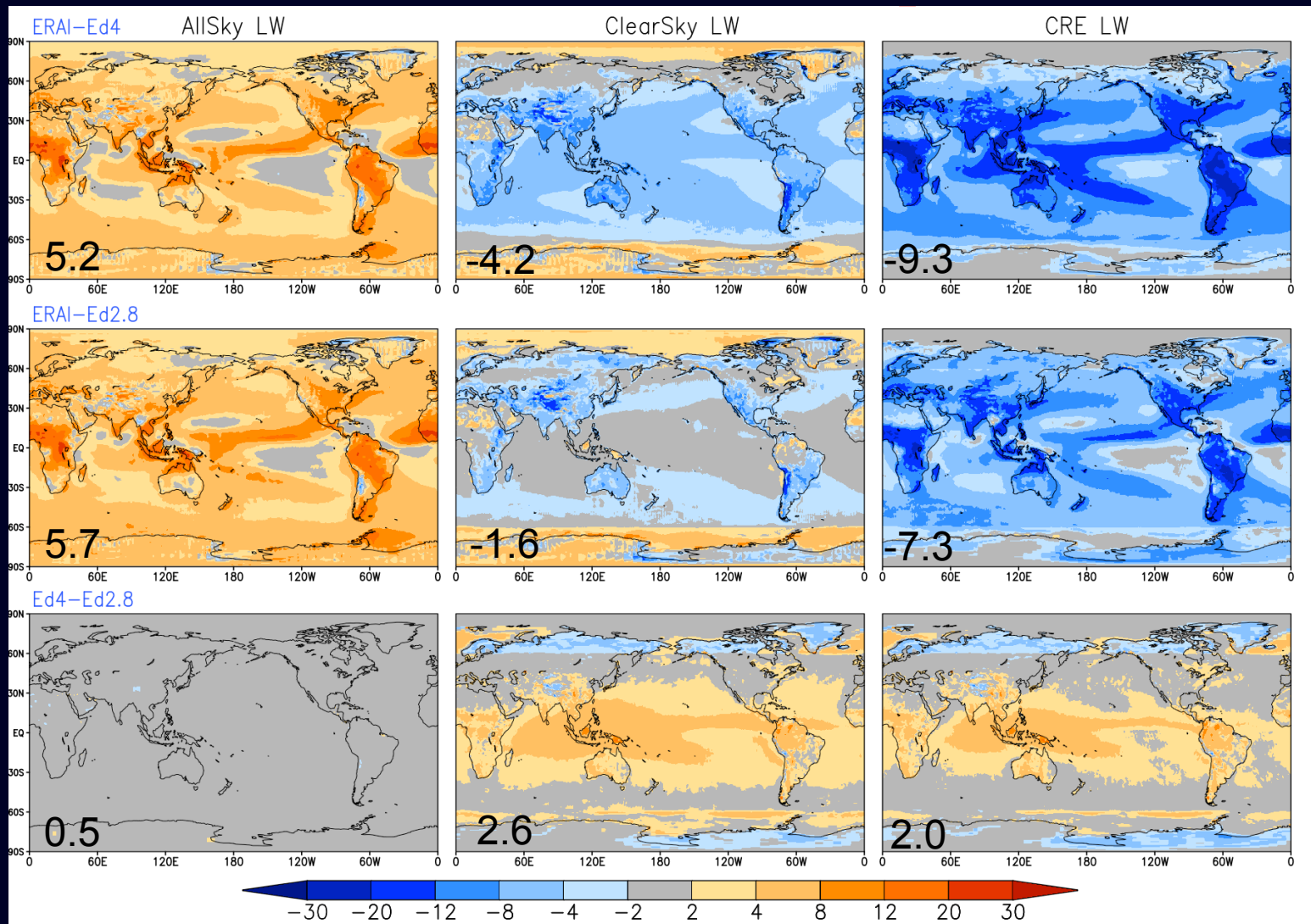
All Sky

Clear Sky

CRE

Mean Climate (2003-2015)

TOA Longwave: ERA-I minus CERES



ERA-I
minus
EBAF4.0

ERA-I
minus
EBAF2.8

EBAF4.0
minus
EBAF2.8

All Sky

Clear Sky

CRE

Mean Climate (2003-2015)

TOA Incoming Solar: Reanalyses minus CERES

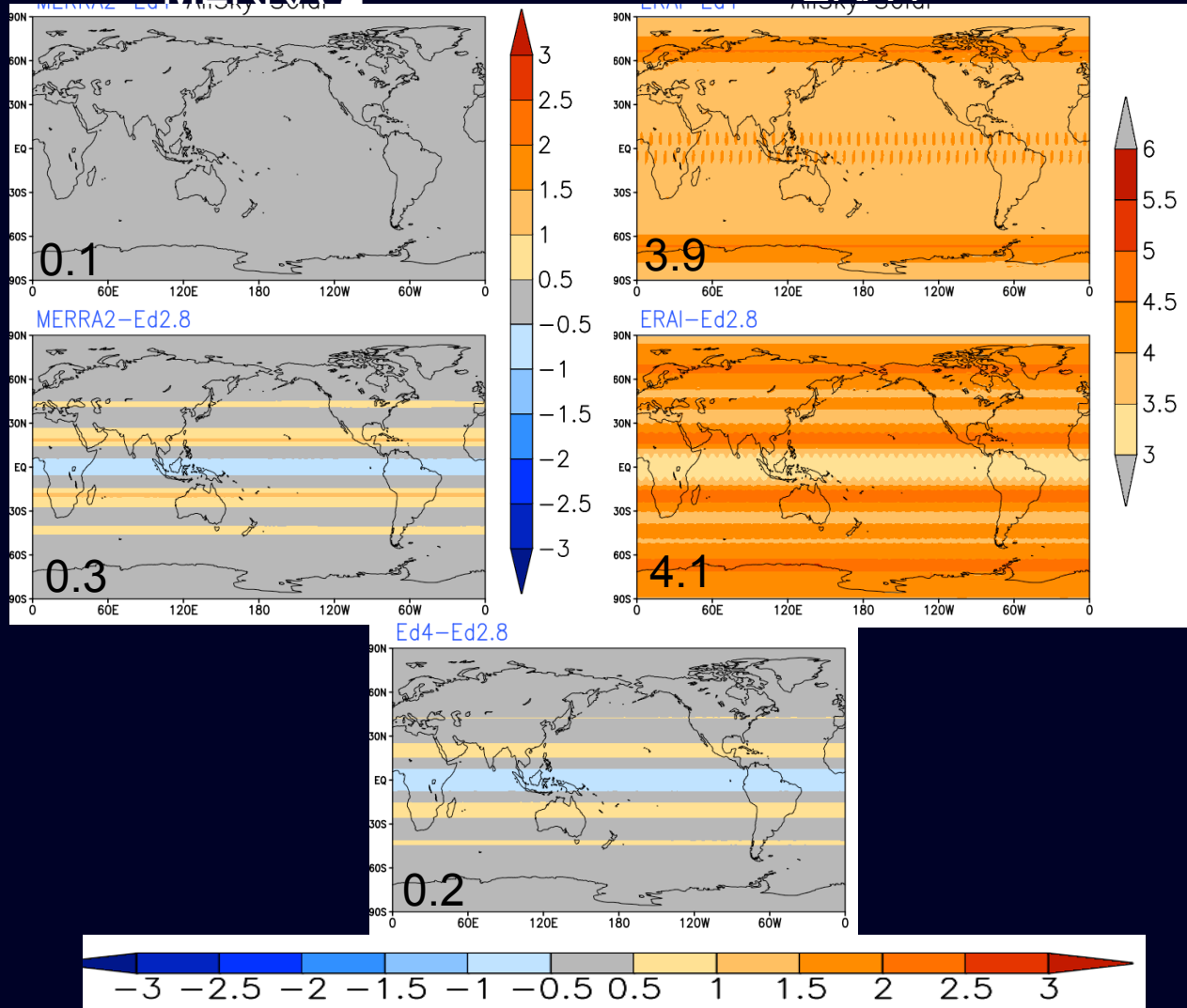
MERRA-2

ERA-I

Reanalyses
minus
EBAF4.0

Reanalyses
minus
EBAF2.8

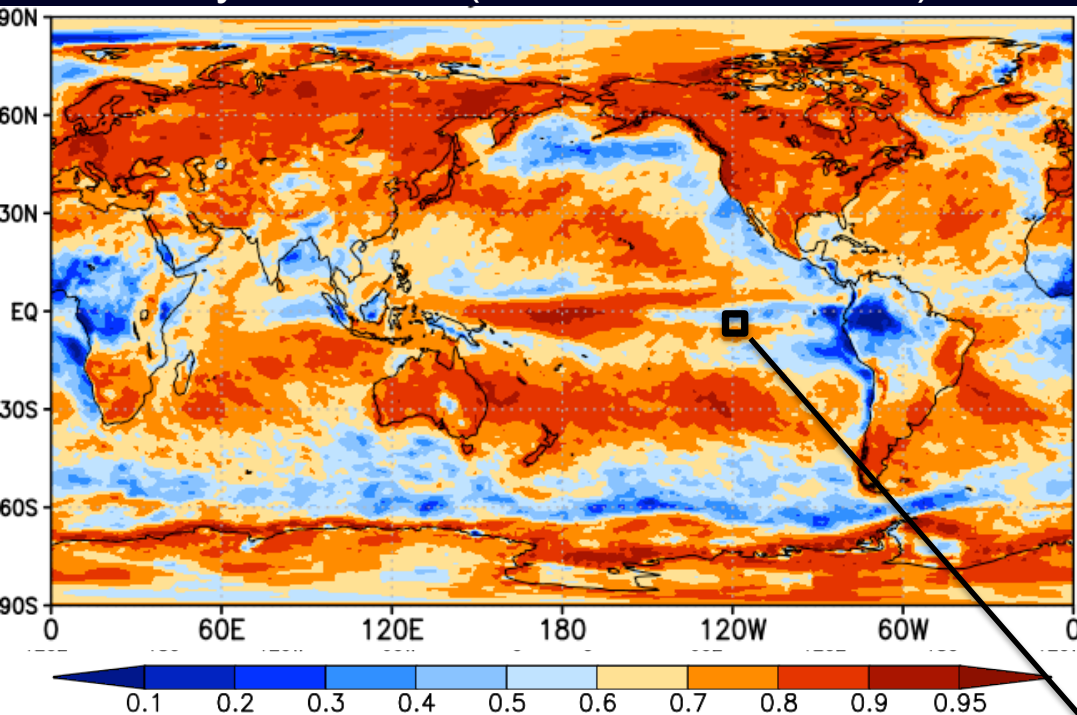
EBAF4.0
minus
EBAF2.8



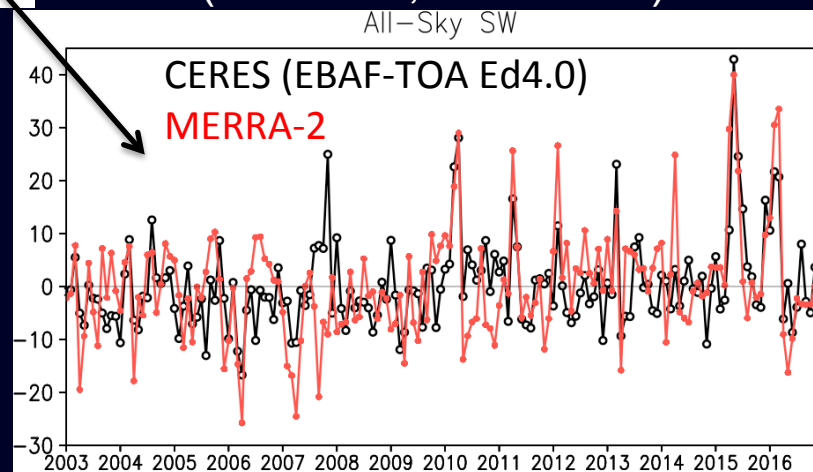
- Reanalyses have better agreements with EBAF4.0, due to the use of GMT time in EBAF4.0.

Year-to-year Variation: Temporal Correlation

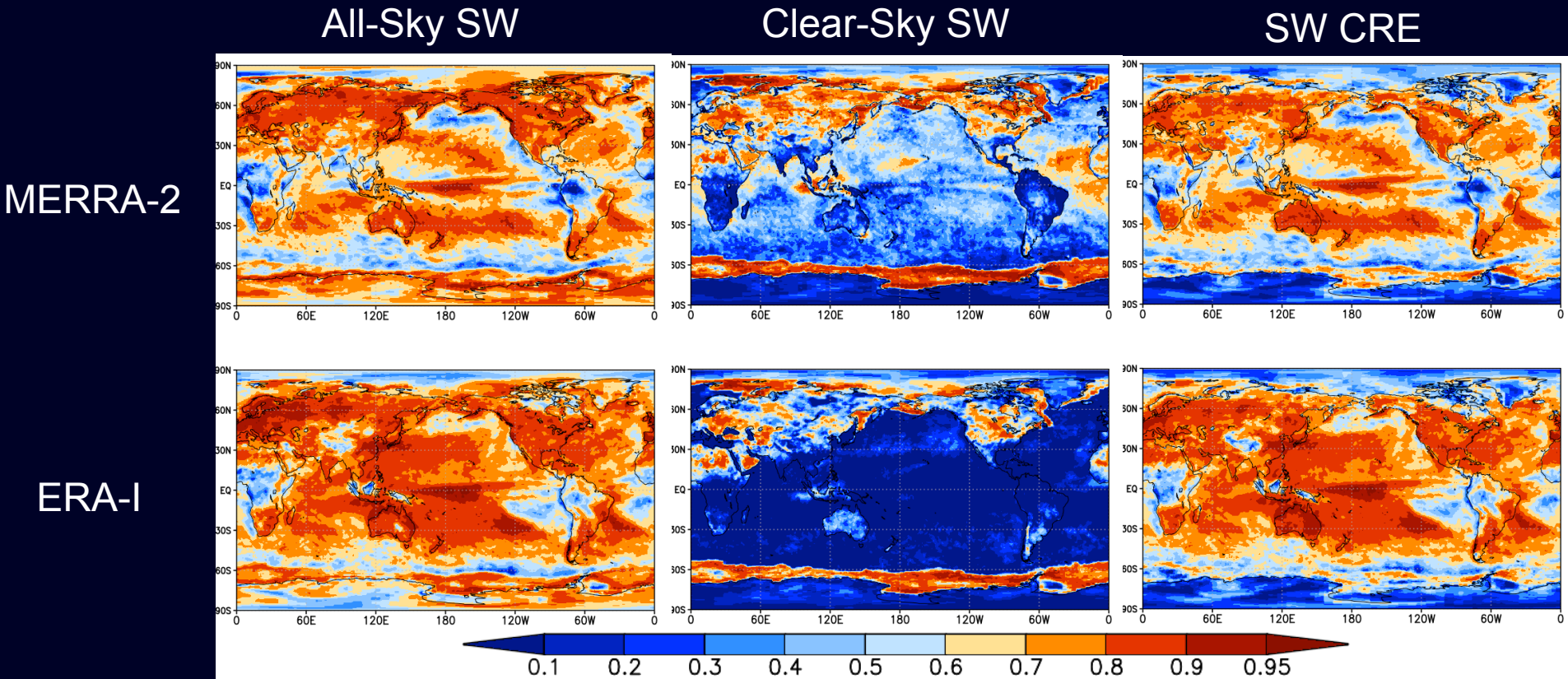
All-Sky SW: tcorr (EBAF4.0, MERRA-2)



All-Sky SW at 120°W0°N
tcorr (EBAF4.0, MERRA-2): **0.53**

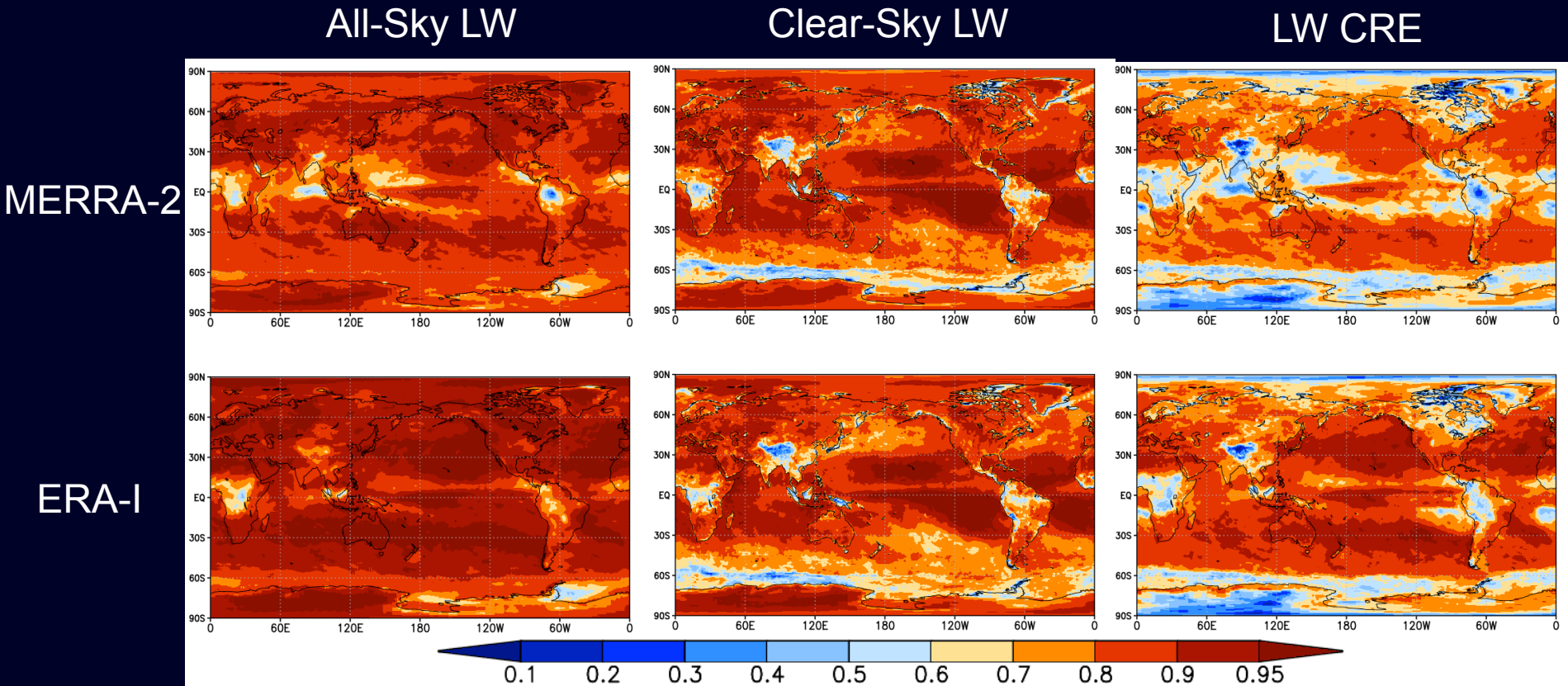


Year-to-year Variation: Temporal Correlation



- **All-Sky SW**: Current reanalyses are subject to their model biases over tropical deep convective regions, subtropical stratocumulus regions, and extratropical oceans (e.g. Southern Ocean);
- **Clear-Sky SW**: reanalyses compute clear-sky SW differently from EBAF4.0;
- **SW CRE**: dominated by all-sky (clear-sky) SW over non-polar (polar) regions.

Year-to-year Variation: Temporal Correlation



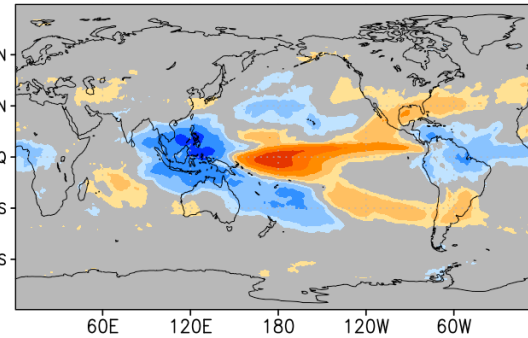
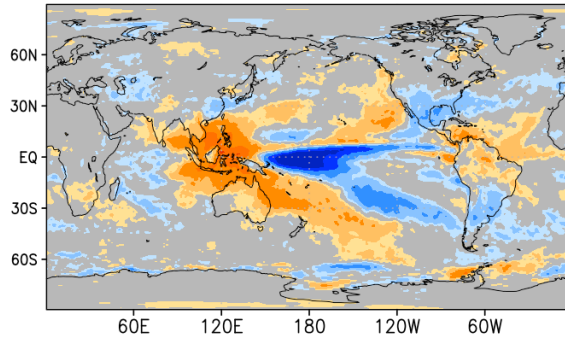
- Better agreement for LW than for SW;
- **All-Sky LW**: Current reanalyses are subject to model performance over tropical deep convective regions, especially over tropical land;
- **Clear-Sky LW**: reanalyses compute clear-sky SW differently from EBAF4.0;
- **LW CRE**: contributed by both all-sky and clear-sky LW.

Year-to-year Variation: ENSO Anomalies

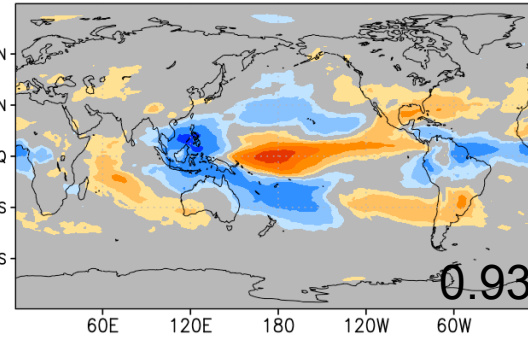
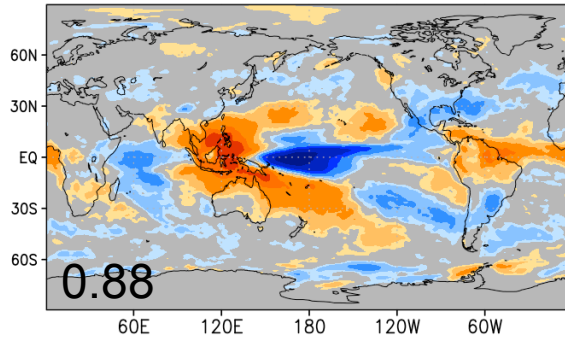
SW CRE

LW CRE

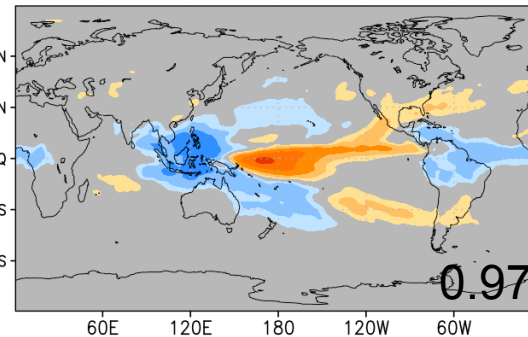
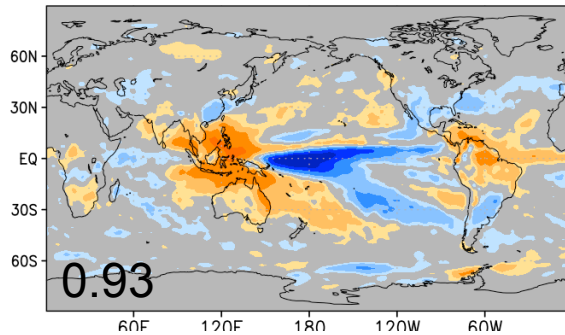
EBAF4.0



MERRA-2



ERA-I



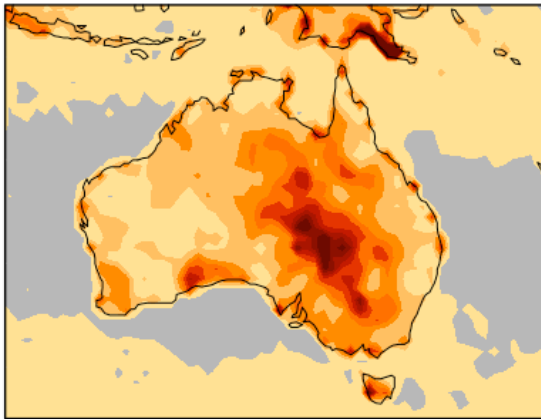
Good agreement



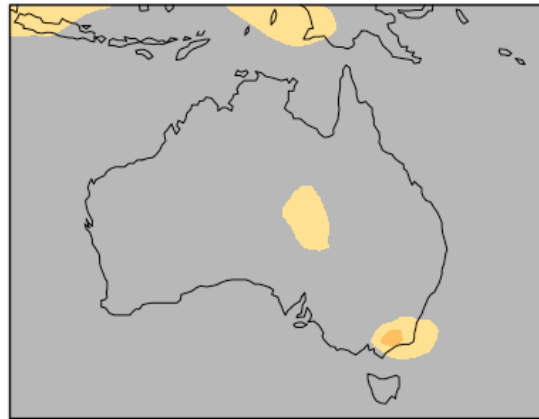
Year-to-year Variation: Standard Deviation

Clear-Sky SW

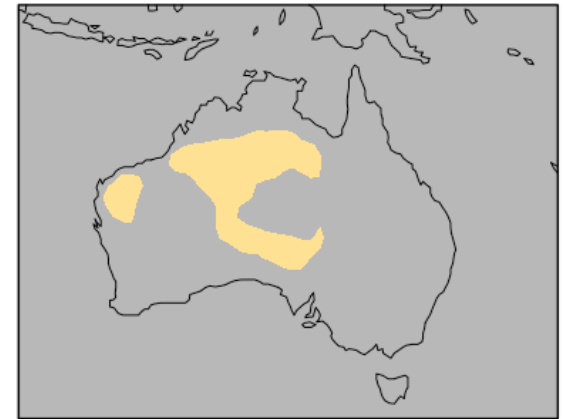
CERES (Ed4.0)



MERRA-2



ERA-I

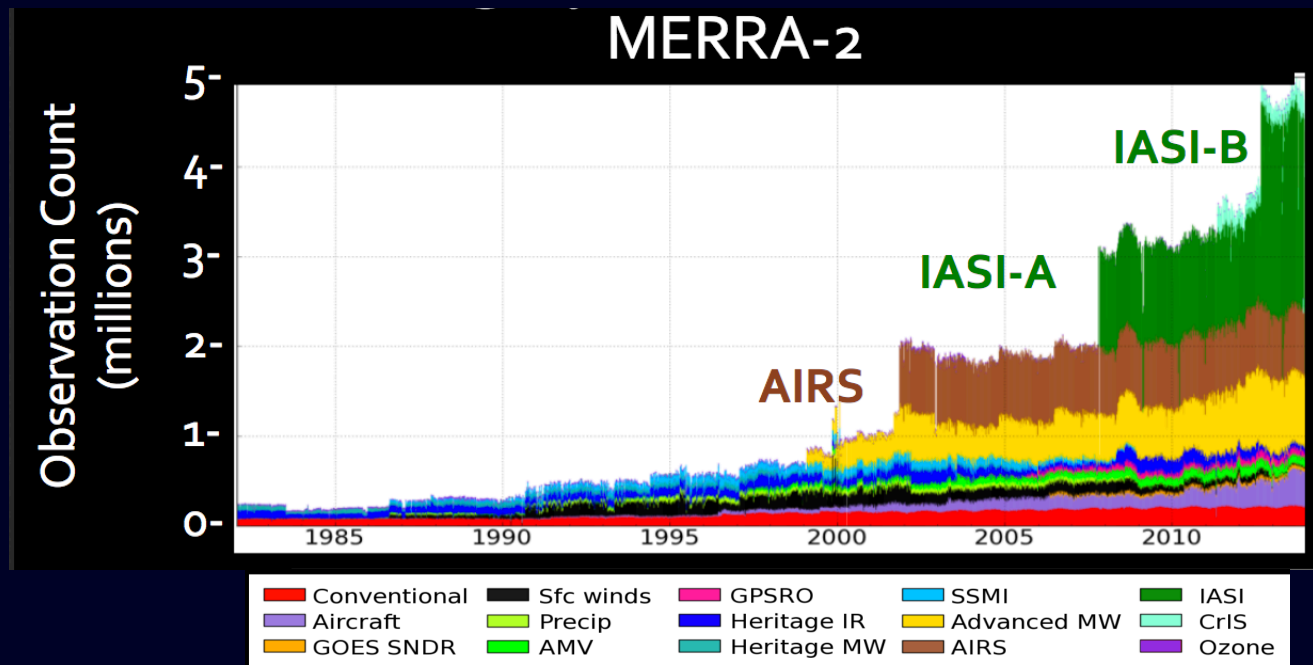


- **Australia:** Millennium drought (2000-2009) followed by post-2010 wet condition; surface vegetation and albedo varied accordingly
- Current reanalyses do not capture observed surface albedo changes associated with vegetation changes, due to the lack of dynamic vegetation process in their land surface models.

Loeb *et al.* (2016)

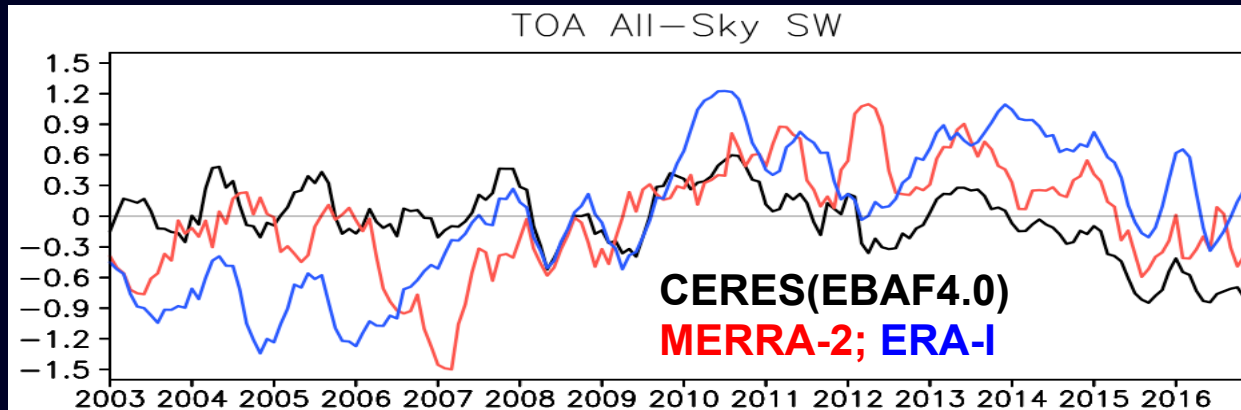
Trend: Controlling Factors

- Natural and anthropogenic climate variations (e.g. ENSO)
- Assimilating model biases in cloud and atmospheric properties, and TOA radiation calculations
- Changes in input observing system

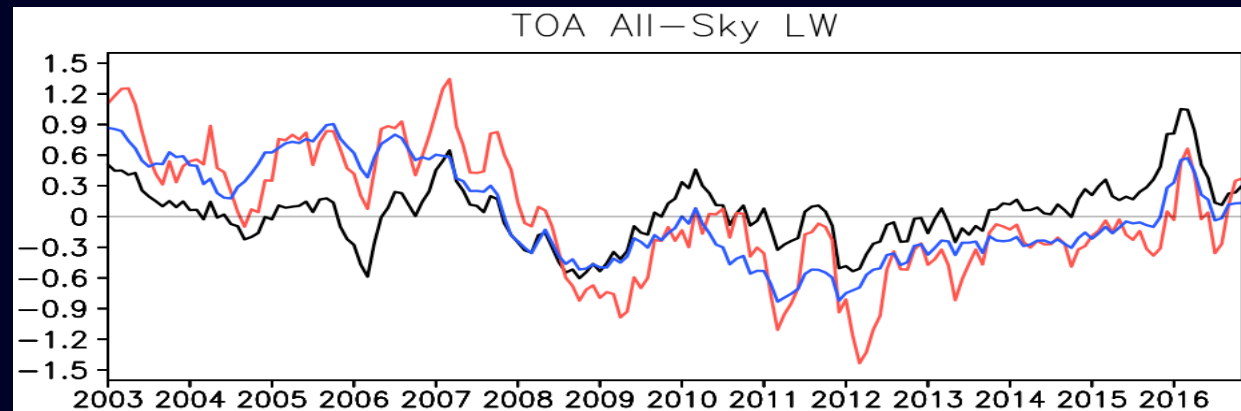


Bosilovich 2015

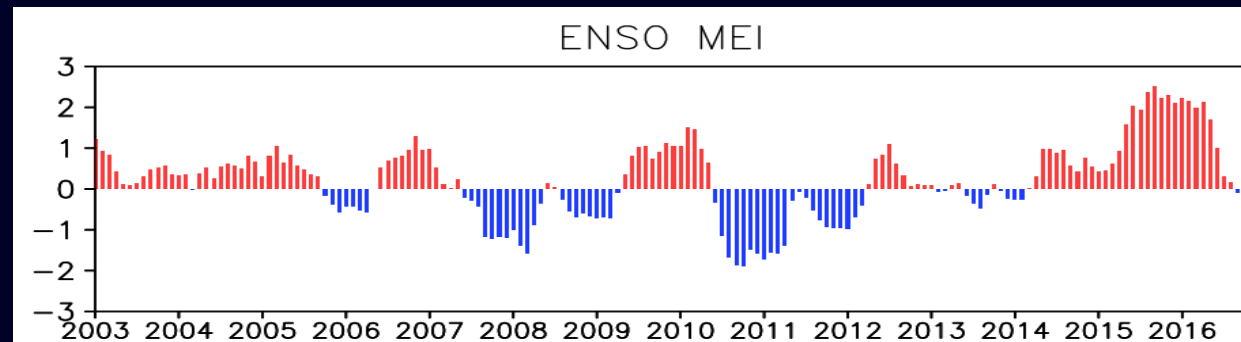
Trend: Global Mean of Deseasonalized Anomalies



All-Sky SW
(5Mon RunMean)



All-Sky LW
(5Mon RunMean)

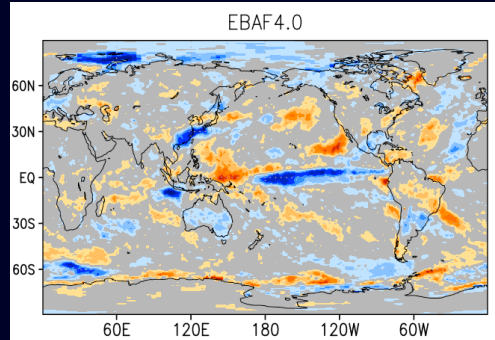


ENSO MEI

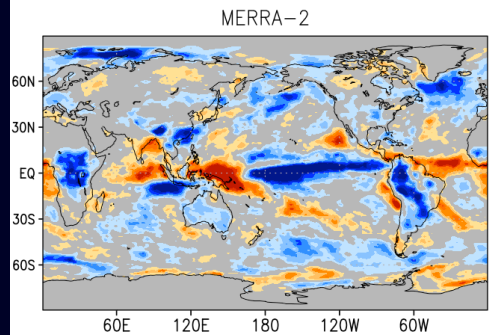
Trend: Jan2003-Nov2016

SW CRE

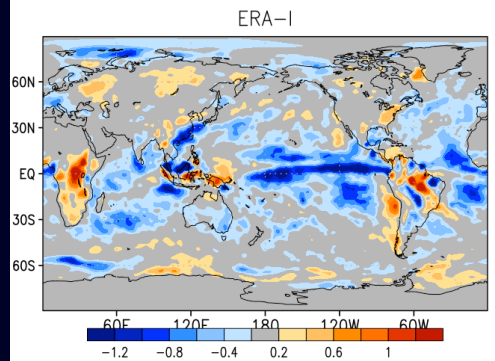
EBAF4



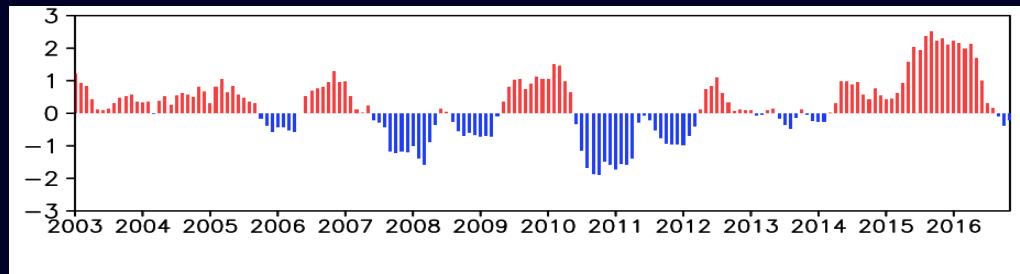
MERRA-2



ERA-I



ENSO MEI



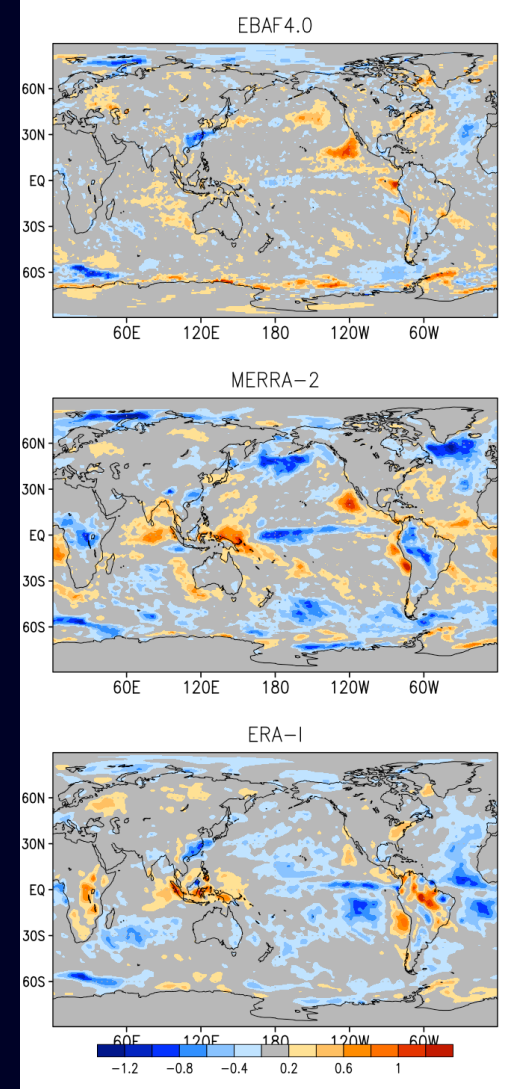
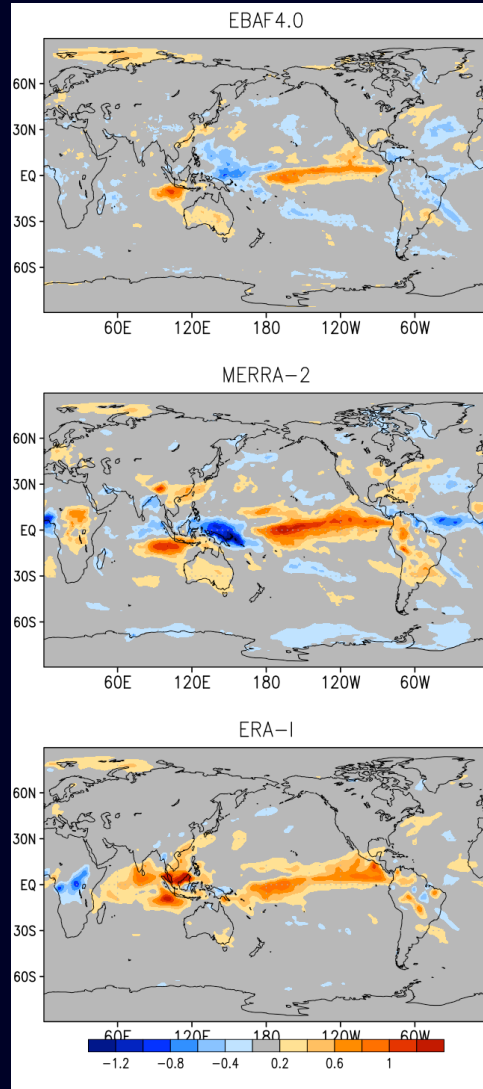
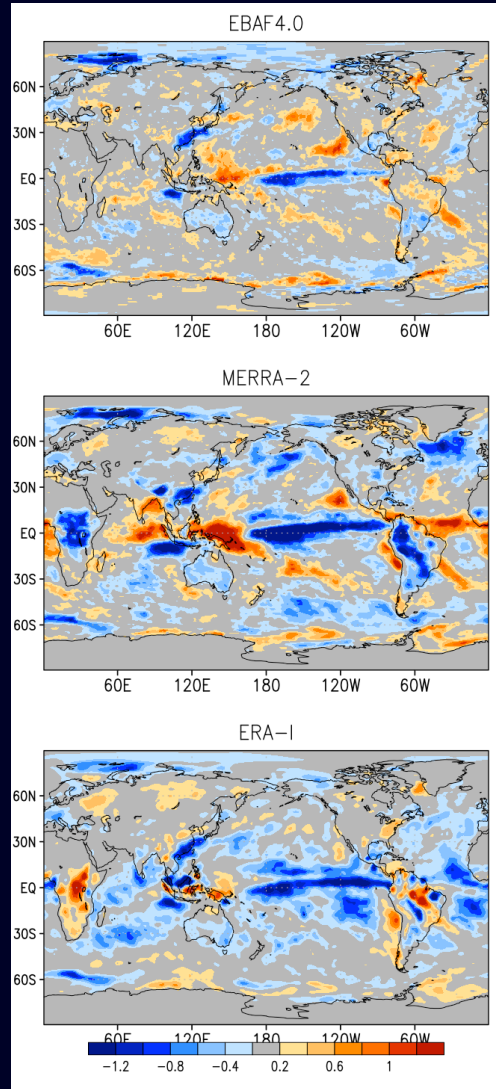
Trend: Jan2003-Nov2016

SW CRE

LW CRE

Net CRE

EBAF4



MERRA-2

ERA-I

Summary

- Effect of EBAF-TOA data improvement on the reanalyses evaluation:
 - all-sky fluxes: negligible; clear-sky fluxes: considerable; CRE: one order smaller than reanalysis biases
- Current reanalyses well capture TOA radiative flux variations associated with ENSO as well as those over the NH land area.
 - Greater performance for LW than for SW
- Current reanalyses are considerably subject to their model performance and changes in the input observing system
 - The models used were challenged in simulating processes over:
 - tropical deep convective regions, especially tropical land
 - subtropical stratocumulus regions
 - extratropical oceans (e.g. Southern Ocean)
 - dynamic vegetation not included in land surface model
 - Trends problematic
 - Diverse performance among the reanalyses